

BASIS FOR THE AMENDMENT

Claims 22 and 40 have been canceled. The limitations of Claim 22 have been included in Claim 1.

No new matter is believed to have been added by entry of this amendment. Entry and favorable reconsideration are respectfully requested.

Upon entry of this amendment Claims 1, 3, 4, 6-17, 19-21, 23-36 and 38, 39, 41 will now be active in this application. Claims 27, 28 and 30-35 stand withdrawn from consideration.

REMARKS

Applicants respectfully request reconsideration of the application, as amended, in view of the following remarks.

Applicants wish to thank Examiner Kessler for the helpful discussion on February 12, 2008. It was discussed to include the limitations of Claim 22 in Claim 1 to overcome Kondo in view of Furuta. The Examiner agreed that this appears to overcome this rejection.

Regarding JP '901 in view of Chen et al it was noted that while the Examiner has admitted that JP '901 fails to disclose a dispersion that contains a surfactant that is different from the lubricant, he has taken the position that it is known to use surfactants to stabilize dispersions. In this context he points to Chen. However, JP '901 and Chen are in different fields of endeavor and thus there is no motivation to combine them.

Similarly, JP '206 and Chen are in different fields of endeavor and should not be combined.

The Examiner indicated that he may consider the case more favorably, if the data from the specification are submitted in the form of a Rule 132 Declaration. Even though the Examiner should consider the data in the specification without such Declaration, Applicants are now attaching a Rule 132 Declaration with the data from the specification.

The rejection of Claims 1, 3, 4, 6, 7, 8, 9, 11, 12, 14, 15, 17, 19, 21, 23, 25, 29 and 38-41 under 35 U.S.C. § 103(a) over Kondo in view of Furuta and the rejection of Claims 1, 3, 4, 6, 7, 17, 19, 29, 37 and 38-41 under 35 U.S.C. § 103(a) over JP 5071206 in view of Chen and JP'901 are obviated by the amendment of Claim 1. Notably, the limitation of Claim 22 has been included in Claim 1. Claim 22 was not rejected over Kondo in view of Furuta; or JP 5071206 in view of Chen and JP'901.

The rejection of Claims 1, 7, 19, 20, 22, 26, 29 and 38-41 under 35 U.S.C. § 103(a) over JP 1997-272901 (JP '901) in view of Chen (US 6,664,018) and the rejection of Claims 14, 16 and 17 under 35 U.S.C. § 103(a) over JP '901 in view of Chen and Kondo '760 and the rejection of Claims 3, 6, 10, 11, 13, 17 and 36 under 35 U.S.C. § 103(a) over JP '901 in view of Chen and Kobayashi are respectfully traversed.

The present invention as set forth in amended **Claim 1** provides a process for compacting a green compact, comprising:

spraying a powdery higher fatty acid-based lubricant which is dispersed in a dispersion comprising a surfactant which is different from said lubricant onto an inner surface of a die, thereby uniformly applying said lubricant onto said inner surface of the die, which is heated;

filling a raw material powder whose major component is an active metallic element into the die;

compacting the raw material powder by warm pressurizing to make a green compact; and

ejecting the green compact from the die;

whereby the resulting green compact has a high density;

wherein the active metallic element is titanium or aluminum;

wherein, in the compacting step, a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact;

wherein the higher fatty acid-based lubricant comprises a metallic salt whose major component is at least one member selected from the group consisting of lithium salts, calcium salts and zinc salts of higher fatty acids.

Claim 36 relates to a process for compacting a green compact, comprising:

spraying a powdery higher fatty acid-based lubricant which is dispersed in a dispersion comprising a surfactant which is different from said lubricant onto an inner surface of a die, thereby uniformly applying said lubricant onto said inner surface of the die which is heated;

filling a raw material powder whose major component is an active metallic element into the die;

compacting the raw material powder by warm pressurizing to make a green compact; and

ejecting the green compact from the die;

whereby the resulting green compact has a high density;

wherein the active metallic element is titanium or aluminum;

wherein, in the compacting step, a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact;

wherein, when the active metallic element is titanium, a green density being an apparent density of the green compact is 85% or more of a true density determined by a composition of the raw material powder; and

wherein, when the active metallic element is aluminum, a green density being an apparent density of the green compact is 90% or more of a true density determined by a composition of the raw material powder.

Based on the present invention, a high-pressure forming of Ti powder and Al powder can be carried out on an industrial scale, **departing from the conventional technical knowledge.**

Regarding JP '901 in view of Chen et al, the Examiner has admitted that JP '901 fails to disclose a dispersion that contains a surfactant that is different from the lubricant. See page 4, first full paragraph of the Office Action of December 14, 2008. Chen. However, JP '901 and Chen are in different fields of endeavor and thus there is no motivation to combine them.

JP '901 relates to a powder molding method while Chen relates to an in-situ method of forming zinc stearate dispersion and use thereof in toners. Thus, a person of ordinary skill in the art working in the field of compacting green compacts would not look at an in-situ method of forming zinc stearate dispersion and use thereof in toners as in Chen and combine that with JP '901. It thus would not have been obvious to use a zinc stearate dispersion made for toners as in Chen for coating a die in JP '901. With all due respect, it makes no sense to use a zinc stearate dispersion used for coating toner particles also for coating a die. There would be no expectation of success.

Further, JP '901 fails to disclose or suggest that the surfactant is different from the lubricant because this reference only discloses a lubricant. JP '901 does not disclose or suggest the use of a surfactant together with the higher fatty acid based lubricant and uniformly applying said lubricant onto said inner surface of the die.

Further, in the process of JP '901, a metal soap film as claimed in the present invention cannot be formed because of the following reasons.

The specification of the present invention discloses at paragraph [0004] as follows:

[0004] In order to utilize the characteristics of green compacts, green compacts are required to have a high density in most cases. In order to produce high-density green compacts, it is inevitable to form raw material powders by pressuring by high pressures. Usually, however, the higher the compacting pressure is, the larger the frictional force between the raw material powders and dies is. As a result, when raw materials are formed by pressuring by large pressures, it has become difficult to eject the resulting green compacts from the dies. Moreover, **galling and the like occur to damage the dies when ejecting the green compacts, or the surface of the green compacts is roughened.**

Paragraph [0011] discloses that:

[0011] However, it has been the technical common knowledge that it is impossible to form raw material powders comprising an active metallic element such as Ti and Al by high pressures at industrial level. This is because galling occurs on the inner surface of dies instantaneously or the inner surface of dies is roughened when such high-pressure compacting is carried out. Moreover, it is because the resulting green compacts cannot be ejected from dies. In addition, very expensive dies cannot be used even after one and only high-pressure compacting operation so that a great loss might arise.

If galling or the like occurs, even though partly, between a formed body and an inner surface of a die, an excellent formed body is not obtained. As a result, the die is damaged, and the duration of life of the die is shortened. Furthermore, decrease of ejection force doesn't occur.

The specification discloses at paragraph [0026]:

[0026] In accordance with the **present compacting process**, even when active metallic powders are used, it is possible to produce high-density green compacts by high-pressure compacting. In this instance, no galling and the like occur on the inner surface of dies substantially, and accordingly it is possible to produce green compacts with favorable dimensional stability and superficial roughness. Therefore, the longevity of dies is extended, the yield of raw material powders is improved, and the working cost is reduced by near net shaping. Thus, it is possible to sharply reduce the cost of green compacts as well as sintered bodies made therefrom.

In order to exhibit the effect of the present invention, it is necessary to form a uniform metal soap film on the surface of the formed body which is opposite to the inner surface of the die.

Here, what becomes important is a die lubrication which is carried out before a pressing and forming process (a compacting process), namely, the spraying step of the present invention.

JP '901 discloses that zinc stearate and the like are dispersed into a solvent to be sprayed to an inner surface of a die. In this conventional metal lubricating method, lubricants such as zinc stearate and the like are merely adhered to the inner surface of the die directly.

The same applies to the case in which lubricants are merely dispersed into a solvent such as water or the like to be sprayed. This is because the solvent such as water or the like is merely used for improving the convenience of spraying, and it is rapidly vaporized on the inner surface of the die. As a result, the lubricants to be sprayed remain on the inner surface of the die in the condition that they are hardly changed.

Such condition means that particulate lubricants are merely adhered to the inner surface of the die due to adhesive force of the lubricants themselves. Furthermore, when particulate lubricants are merely dispersed into water or the like, the lubricants and water becomes the condition that they are easily separated from each other, and it is difficult to carry out a uniform coating on the inner surface of the die.

In this manner, if metal powder is filled in an inner surface of a die to which lubricants are merely adhered, the lubricants are easily peeled off from the inner surface of the die one after another by contacting with the metal powder because adhesive force between lubricants and the inner surface of the die is weak. Then, the portion where the metal powder is directly brought into contact with the inner surface of the die increases, and galling or the like occurs between an outer surface of a formed body and the inner surface of the die. As a result, an excellent high-pressure formed body is not obtained, and decrease of ejection force doesn't occur.

Further, if zinc stearate is used as lubricant, it is dissolved at the temperature of 150°C, and **a uniform lubricant film is not formed.**

On the contrary, in the present invention, a higher fatty acid-based lubricant is once dispersed into water containing surfactants, and then, such dispersion liquid is applied to an inner surface of a die uniformly, thereby carrying out metal lubrication.

Due to existence of surfactants, metallic salt of the higher fatty acid such as lithium stearate which is hardly dissolved into water is dispersed into dispersion liquid uniformly and

finely. When such dispersion liquid is applied to the inner surface of the die, metallic salt of the higher fatty acid is adhered to the inner surface of the die uniformly and closely (without space). Furthermore, by adjusting the density of metallic salt, it is possible to form a thin and uniform lubricating film on the inner surface of the die easily.

Moreover, the surfactants make viscosity of the dispersion liquid higher, so they exhibit the effect that metallic salt of the higher fatty acid is strongly adhered to the inner surface of the die. At this time, the dispersion liquid is applied to the inner surface of the heated die to be a so-called baking finish condition, and a strong lubricant film is formed on the inner surface of the die. Even if the lubricant film is brought into contact with metal powder which is filled in the die, peeling, defects and the like don't occur easily. As a result, a pressing and forming process (a compacting process) is carried out under the condition that the lubricant film comprising metallic salt of higher fatty acid is uniformly formed between the metal powder and the inner surface of the die. Then, a metal soap film is stably formed on the whole surface of a formed body which is opposite to the inner surface of the die, and an excellent high-pressure formed body is obtained. In addition, it is possible to eject the formed body from the die with low ejection force even if the formed body comprises Ti or Al.

JP '901 describes that metallic salt of higher fatty acid is dispersed into water, but JP '901 does not disclose or suggest the use of surfactants, which is disclosed in the present invention.

In the present invention, the surfactants have a role in forming the lubricating film comprising metallic salt of higher fatty acid on the inner surface of the die stably. Namely, when the dispersion liquid is applied to the inner surface of the heated die, moisture and the like are rapidly vaporized, but the surfactants themselves remain without being vaporized. The remained surfactants work as a filler for fixing the metallic salt of higher fatty acid to the

inner surface of the die. Such effects of surfactants are not obvious to a person of ordinary skill in the art based on JP '901.

In JP '901, even if there is the possibility that a metal soap is generated, **it is merely a very small portion between the surface of the formed body and the die, BUT NOT A FILM as claimed.** This is because, in the metal lubrication method of JP '901, higher fatty acid-based lubricants (zinc stearate in JP '901) are adhered to the inner surface of the die merely in a dotted manner, and additionally, the lubricants are peeled off when the metal powder is filled in the die. Thus a uniform lubricant film is not formed which is necessary for generating a metal soap film.

In JP '901, neither a metal soap film nor the lowering of the ejection pressure are described.

Further, US '760 fails to disclose or suggest the use of Ti or Al. Thus, it is not proper to combine US '760 with JP '901. Even if combined, there would be no expectation of success in making a green compact from Ti or Al.

Kobayashi does not cure the defects of JP '901 as it also fails to disclose or suggest that a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact.

Moreover, superior properties are achieved when using the warm compacting as shown by the Examples in the specification now submitted in the form of a **Rule 132 Declaration.**

When compacting is done at **room temperature** as in the Comparative examples, the green compact density, the relative density of the green compact, the sintered body density, the relative density of the sintered body become small. In addition, large dimensional changes before and after sintering occur. Please see the **Table 1** below which is reproduced

from page 44 of the specification and **Figures 1-4 and 8 and 9 of the specification**. On the other hand, using the **process according to the present invention, excellent green compact density, excellent relative density of the green compact, excellent sintered body density, and excellent relative density of the sintered body are achieved. In addition, the dimensional changes before and after sintering are much smaller than in the Comparative Examples**. The superior properties obtained using the process of the present invention are not disclosed or suggested by JP '901, Chen, Kondo '760 and Kobayashi, either alone or in combination.

Due to the low dimensional changes and high precision, the cost for post sintering conversions can be eliminated and the obtained components can be manufactured for about the same cost as conventional steel components. For example, the specification states at pages 29-31 as follows:

In particular, when the active metallic element is Ti, the green compact and metallic sintered body resulting therefrom according the present invention offer incredible effectiveness. Conventionally, in the fields of aviation, space and military, titanium alloys which are lightweight and exhibit high strength (i.e., which are good in terms of the specific strength) have been used in a large volume. However, titanium alloys haven been hardly applied to consumer products which are mass-produced generally. In particular, iron or steel materials have been often used in mass-produced exclusive component parts. However, there has been no example in which titanium alloys are applied to the mass-produced exclusive component parts instead of the iron or steel materials. This is because the manufacturing cost has gone up sharply when titanium alloys are used. Thus, titanium alloys are not adequately applied to mass-produced component parts which are required to be low cost. The biggest factor heightening the manufacturing cost is that not only the material cost is expensive but also the secondary working cost is extremely high when the workpieces are worked into the respective component parts. This is because the workpiece shapes of titanium alloys are limited.

On the other hand, when the present compacting process, sintering process and working method are used, it is possible to produce component parts made of titanium alloys, which are lightweight and are good in terms of the strength, without substantially generating the high secondary working cost. Accordingly, it is possible to substitute a variety of mass-produced component parts made of titanium alloys for those conventional ones made of iron or steel materials.

As for such mass-produced component parts, there are automotive component parts

which require all sorts of strength, a variety of sporting goods and tools, for example. More specifically, the automotive component parts can be automotive engine component parts such as engine valves, valve retainers, valve lifters, piston pins, valve guides, connecting rods and rocker arms. Moreover, the automotive component parts can be power transmission component parts such as gears, driving shafts and blocks for CVT (i.e., continuously variable transmission). The sporting goods can representatively be golf clubs such as drivers, irons and putters.

Moreover, when the present compacting process, sintering process or working method is applied to conventional die-forming designing, it is possible to form cylinder-shaped component parts, such as billets for extrusion, piston pins, valve guides, valve retainers, connecting rods, blocks for CVT, irons and putters.

In addition, when the present compacting process, sintering process or working method is applied to advanced forming processes such as CNC (i.e., computer numerically controlled) pressing, it is possible to form engine valves, valve lifters, rocker arms, gears, driving shafts and golf-club heads.

TABLE 1

Sample No.	Composition (% by mass)	Compaction pressure (MPa)	Ejection Force (MPa)	Green Compact		Metallic Sintered Body				Note
				Green-compact Density (g/cm ³)	Relative Density (%)	Outside Dia. after Ejection (mm)	Sintered-body Density (g/cm ³)	Relative Density (%)	Dimension Change before and after sintering (%)	
Ex.	1-1	588	3.5	4.025	89.2	23.059	4.325	95.9	-2.60	
	1-2	784	1.9	4.193	93.0	23.061	4.384	97.2	-1.59	
	1-3	980	2.4	4.292	95.2	23.065	4.451	98.7	1.37	
	1-4	1176	2.5	4.364	96.8	23.070	4.496	99.7	-1.11	
	1-5	1372	2.6	4.391	97.4	23.075	4.501	99.8	-0.87	
	1-6	1568	2.2	4.422	98.0	23.079	4.505	99.9	-0.60	
	2-1	784	0.9	3.991	91.1	23.065	4.403	99.3	-3.26	Mixture Powder of Pure Ti Powder and Alloy Powder
	2-2	1176	0.5	4.201	95.9	23.071	4.407	99.4	-1.61	
	2-3	1568	0.5	4.285	97.8	23.081	4.412	99.5	-0.96	
	3-1	784	5.1	3.956	90.2	23.072	4.332	97.4	-3.04	Mixture Powder of said Mixture powder and Hard-particle Powder TiB ₂ : 6% by mass
	3-2	1176	3.6	4.143	94.3	23.078	4.395	98.8	-2.06	
	3-3	1568	2.7	4.234	96.5	23.083	4.412	99.2	-1.46	
	4-1	392	0.3	2.613	96.8	22.997	-	-	-	
	4-2	588	0.7	2.656	98.4	22.992	-	-	-	
	4-3	784	0.7	2.672	99.0	22.994	-	-	-	
	4-4	980	0.7	2.682	99.4	22.994	-	-	-	
	4-5	1176	0.8	2.686	99.5	22.993	-	-	-	
	4-6	1372	0.8	2.667	99.8	22.994	-	-	-	
	4-7	1568	0.5	2.667	99.8	22.995	-	-	-	
Comp. Ex.	5-1	588	1.3	2.616	93.4	23.014	-	-	-	Equivalent to JIS A7475
	5-2	980	1.1	2.741	97.9	23.029	-	-	-	
	5-3	1568	1.4	2.794	99.8	23.038	-	-	-	
	C1-1	294	8.0	3.209	71.2	23.068	4.235	93.9	-9.58	Room-temp. Compaction
	C1-2	441	16.3	3.521	78.1	23.075	4.290	95.1	-6.94	
	C1-3	588	24.1	3.728	82.9	23.082	4.300	95.3	-4.95	
	C2-1	392	4.1	2.583	95.7	23.056	-	-	-	Room-temp. Compaction
	C2-2	588	5.7	2.615	96.9	23.057	-	-	-	
	C2-3	784	6.5	2.640	97.8	23.059	-	-	-	

Only when all claimed conditions (including the warm pressurizing) are satisfied, the ejecting force can be decreased substantially.

For example, as for warm pressurizing, there is the description that “the alcohol-based solvents evaporate instantaneously so that it is possible to form a uniform lubricant film with ease” in [0068] of the specification.

It has been the technical common knowledge that it is impossible to form raw material powders comprising an active metallic element such as Ti and Al by high pressures at industrial level. This is because galling occurs on the inner surface of dies instantaneously or the inner surface of dies is roughened when such high-pressure compacting is carried out. Moreover, it is because the resulting green compacts cannot be ejected from dies. In addition, very expensive dies cannot be used even after one and only high-pressure compacting operation so that a great loss might arise. See paragraph [0011] of the specification.

In addition, the green compacts have a low density because the pressure cannot be increased. For example, when green compacts comprise a Ti powder, the green compacts have a density which is only 80% or less of the true density. See paragraph [0012] of the specification.

Moreover, when Ti powders are formed conventionally by pressuring using an internal lubrication method, a dewaxing step is required additionally before the resulting green compacts are sintered in vacuum. In addition, since the major components of the lubricants used in this instance, such as hydrogen, nitrogen and carbon, are likely solve in Ti, internal lubrication methods are unpreferable. See paragraph [0013] of the specification.

Another concern is the low dimensional accuracy of the green compacts. See paragraph [0014] of the specification.

In case of Al powders there is an additional concern that when Al powders are mixed with lubricants and are formed thereafter, it is impossible to dewax sufficiently because the dewaxing temperature of the lubricants is close to 500 °C approximately, the sintering temperature of the resulting green compacts.


Therefore, the rejection of Claims 1, 7, 19, 20, 22, 26, 29 and 38-41 under 35 U.S.C. § 103(a) over JP 1997-272901 (JP '901) in view of Chen (US 6,664,018) and the rejection of Claims 14, 16 and 17 under 35 U.S.C. § 103(a) over JP '901 in view of Chen and Kondo '760 and the rejection of Claims 3, 6, 10, 11, 13, 17 and 36 under 35 U.S.C. § 103(a) over JP '901 in view of Chen and Kobayashi are believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of these rejections is respectfully requested.

This application presents allowable subject matter, and the Examiner is kindly requested to pass it to issue. Should the Examiner have any questions regarding the claims or otherwise wish to discuss this case, he is kindly invited to contact Applicants' below-signed representative, who would be happy to provide any assistance deemed necessary in speeding this application to allowance.

Respectfully submitted,

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